Computing Functional Urban Areas Using a Hierarchical Travel Time Approach: An Applied Case in Ecuador

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Outline

- **Introduction**
- **The proposal**
- **Sensitivity test**
- **Robustness checks**
- **Conclusions**

Administrative boundaries ≠ Economic boundaries

SMA, LLMA (TTWA), **FUA**, FUR, Regionalization……

-To collect information

-To develop public policies

-Normative use

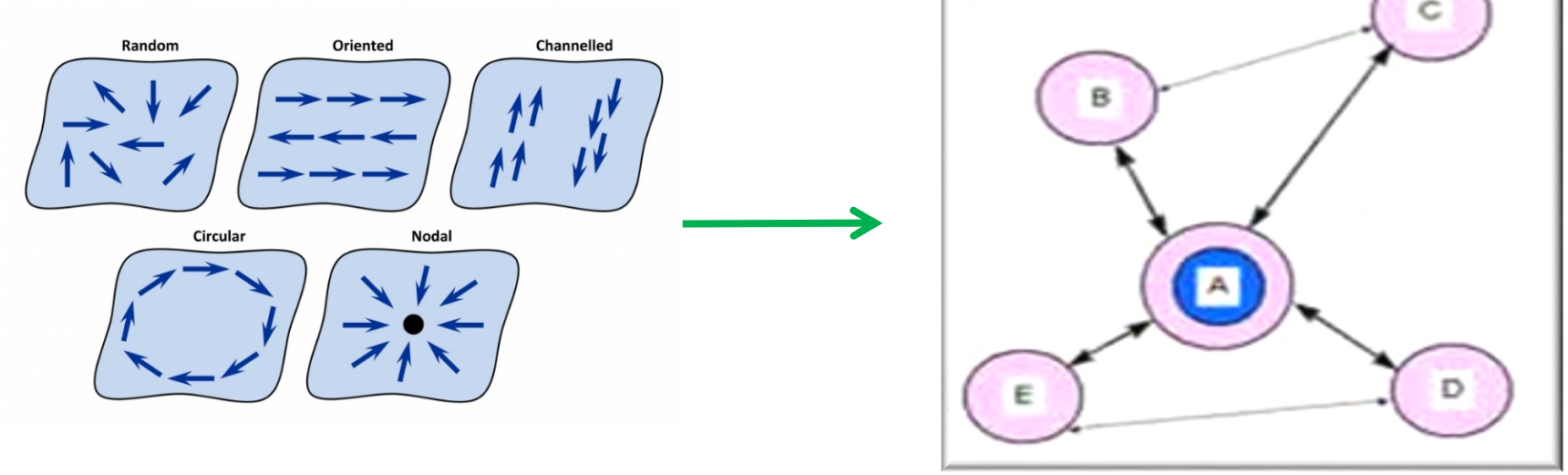
Modifiable area unit problem (MAUP) is an inseparable part of almost any spatial analysis… (Klapka et al., 2014)

The correct identification of MAUP should reduce problems associated to mismeasurement of the size of the local economy (Briant et al. 2010)

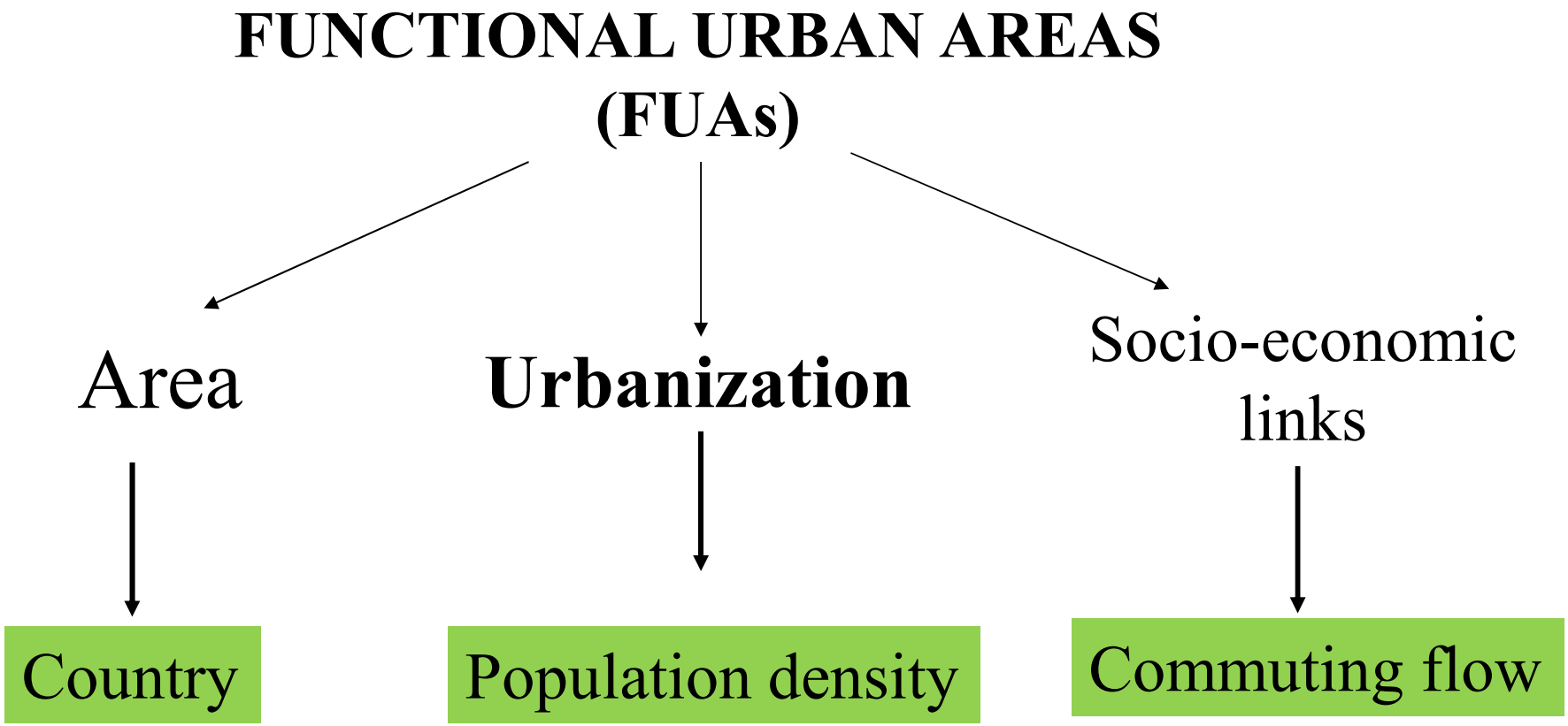
Administrative boundaries ≠ Economic boundaries

-There is not a consensus of the best approach (Halás et al., 2015)

-Different approaches give different results and the same approach can give sharply different at different thresholds (Klapka et al., 2014)



Introduction



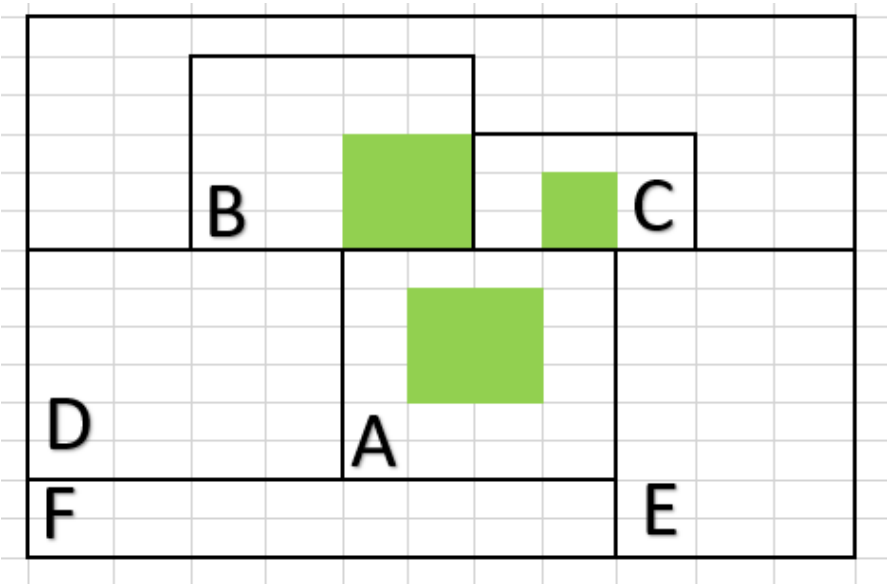
OECD Methodology: 3 steps

1. Identifying urban cores:

❖Grid cells of high population density (1,000 – 1,500 inhab./km^2).

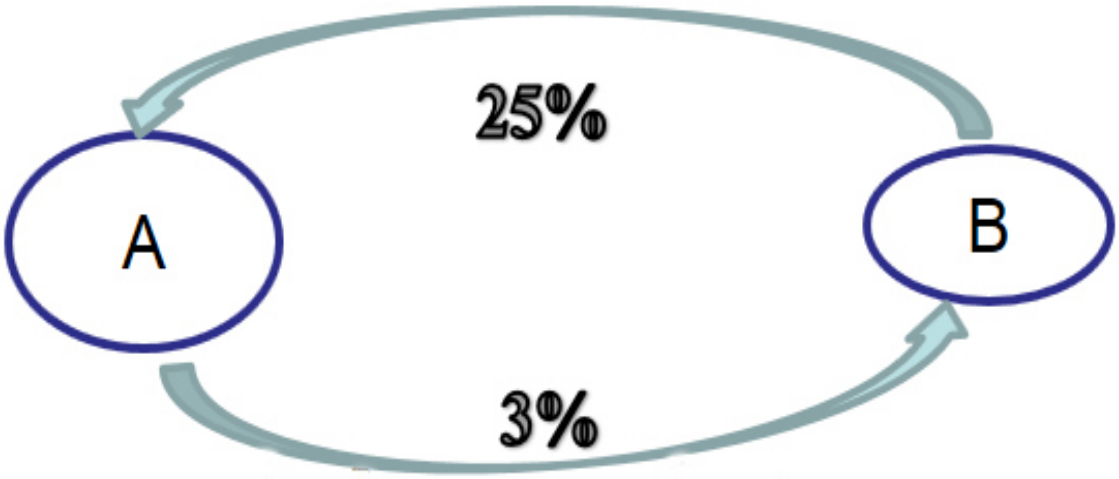
❖Clusters of contiguous high population density (50,000 – 100,000 inhab. to be an urban core)

❖Municipality of reference (at least 50% of population)



OECD Methodology: 3 steps

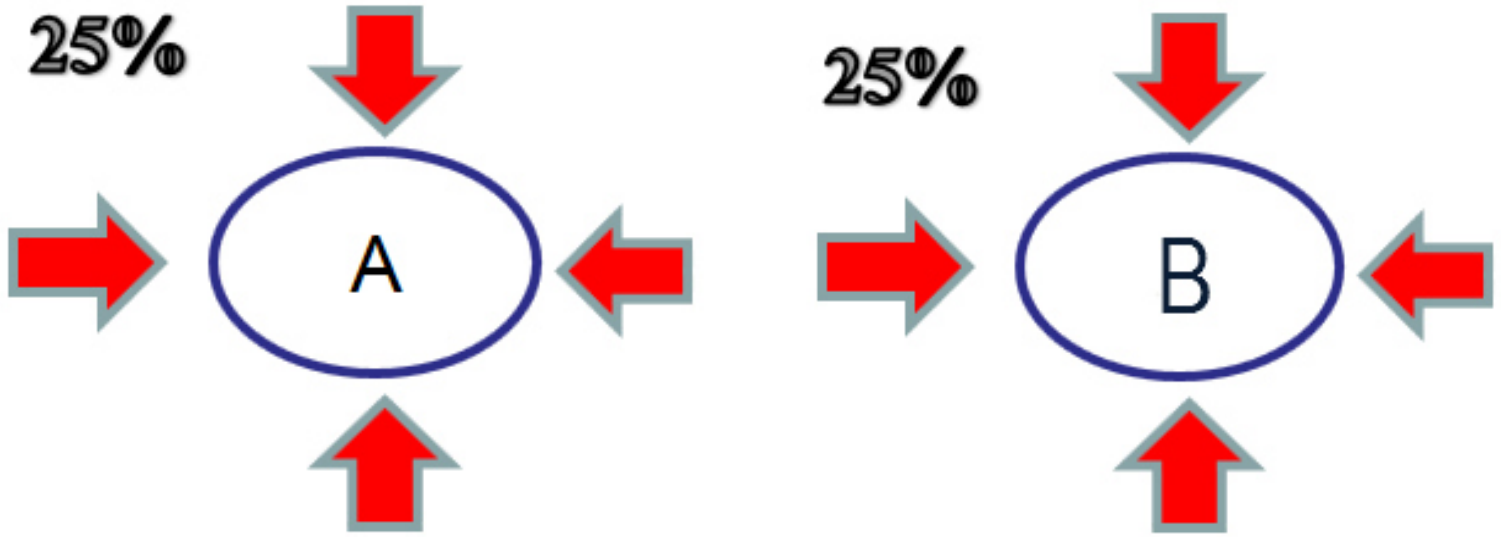
2. Connecting non-contiguous urban cores that belong to the same FUA: among areas of reference of urban cores (at least 15-50% of commuting flow)



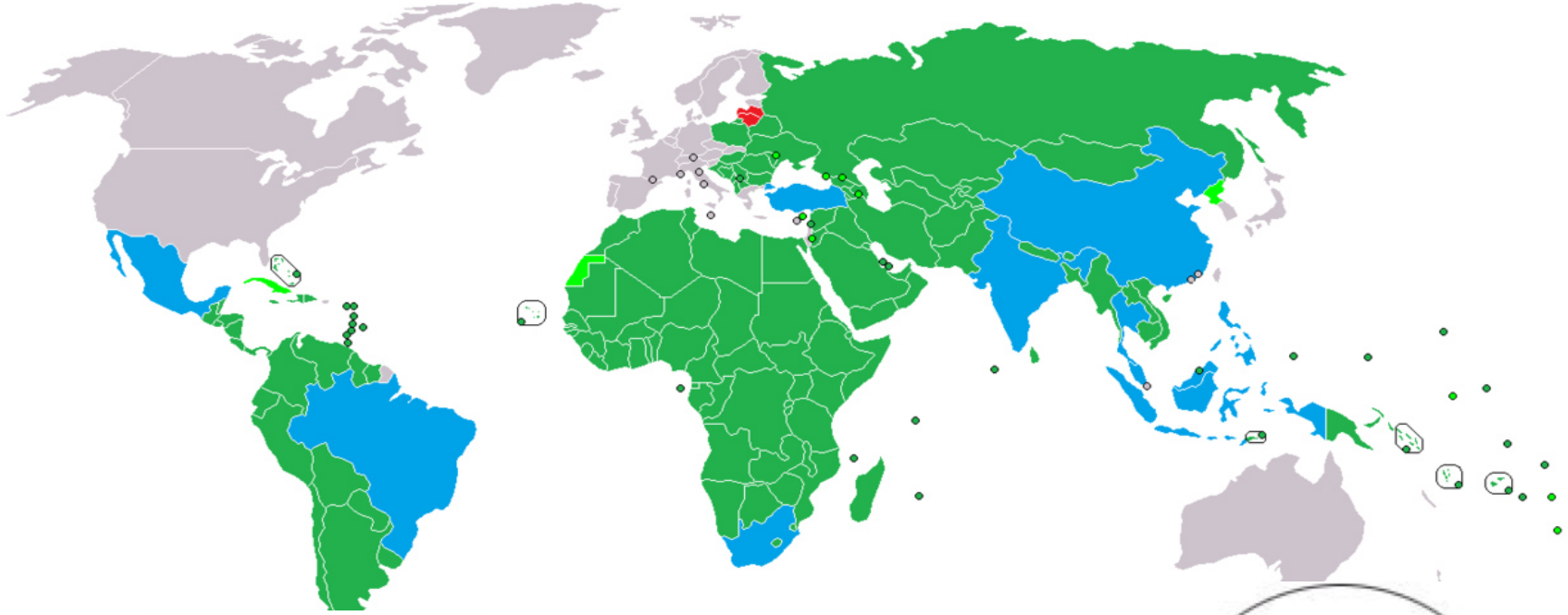
Commuting flow is hierarchical

Introduction

3. The hinterland: surrounding areas that are mot urban cores to each urban core (at least 15-50% of commuting flow)



The problem….?



Commuting census

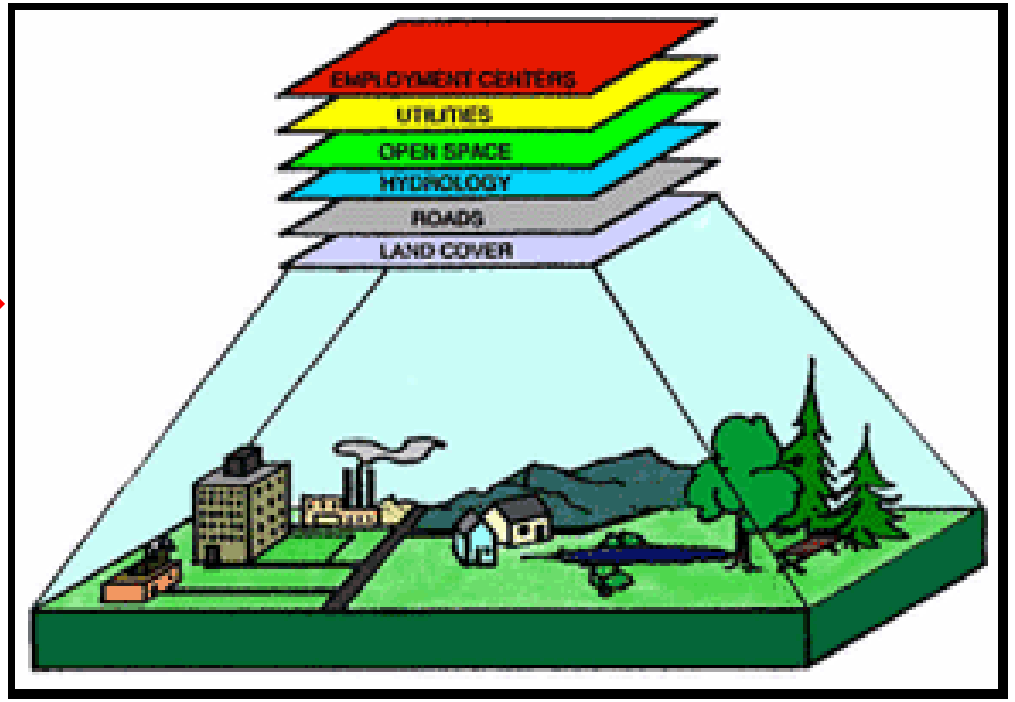
The Objective..

We are able to identifying FUAs in a suitable way using GIS data and travel time

LandScan™

mapquest

OpenStreetMap



The proposal !!

Following OECD methodology

1. **Identifying Urban Cores:**
   - ✓ High density grid cells in 1 km^2
   - ✓ Cluster of high population density (Extra rules)
   - ✓ Minimum size of self-containment
2. **Connecting non-contiguous Urban Cores**:
   - ➢ An algorithm that uses travel time applied in a hierarchical procedure on the road network.
3. **Defining hinterland:**
   - ➢ Radius of influence from the center of each urban core: $t_i = \frac{2}{3} * \sqrt{A_i \pi} \ / \ v$; (Ahlfeldt & Wendland, 2015)

Application

ECUADOR:

- Small Open Developing Economy
- Not other important transportation system
- Average of population size and geographical characteristics

Application

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DATA:

- **1st step)** LandScan 2013 database –used OECD (Raster data of 1 km^2 in SHP) → QGIS

- **2nd step)** Google map service (Stratification Algorithm, road information) → STATA*

- **3rd step**) Open Street Map (Isochrones-road information) → QGIS

- **Administrative level**: INEC (Parishes-level3)

Application

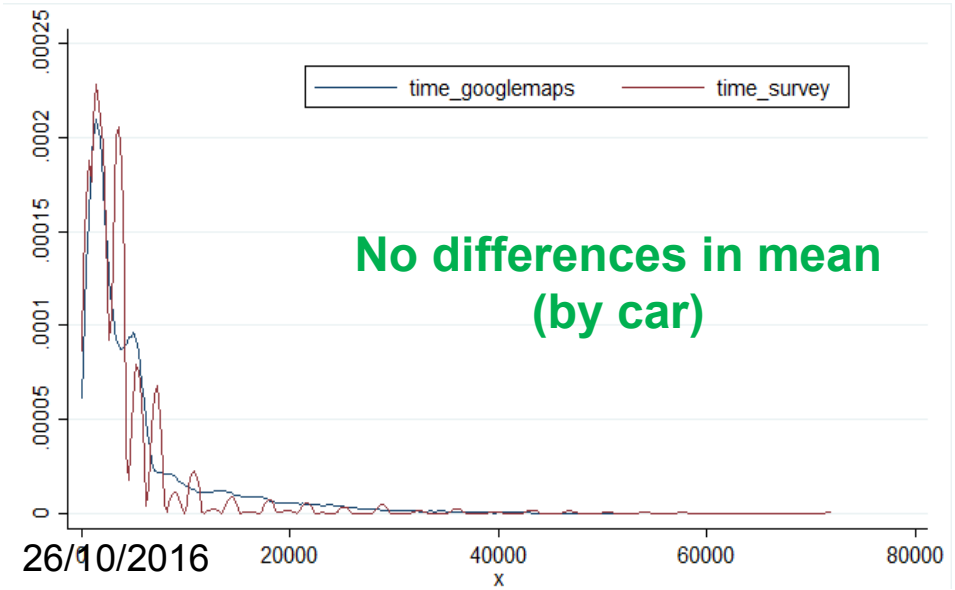
Setting the minimum thresholds

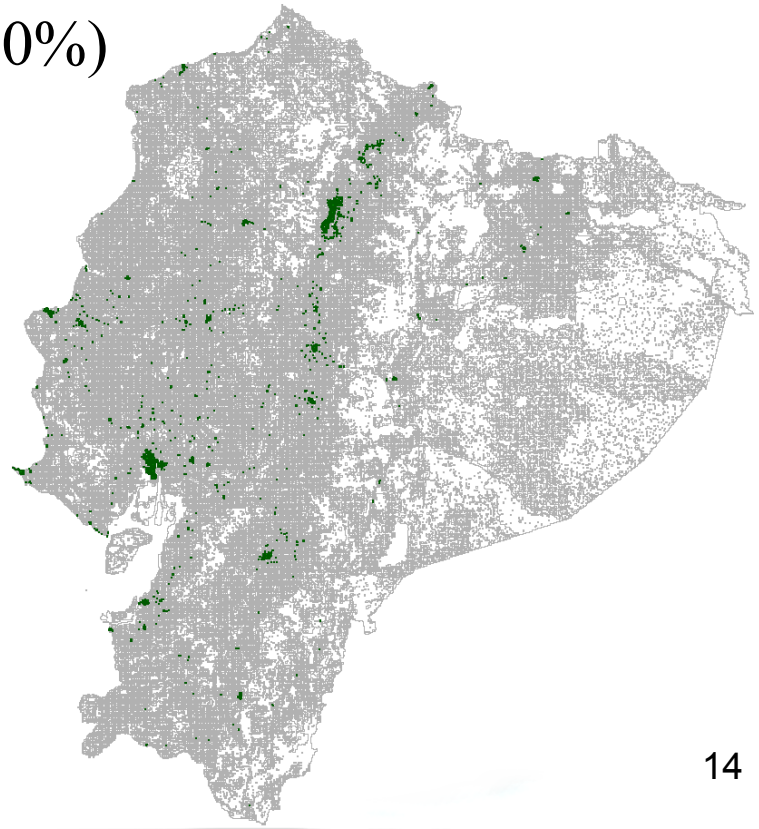
MINIMUM THRESHOLD FOR URBAN CORES:

- Half values applied in developed economies as starting point
- 500 inhb/km^2 and 25,000 inhb. urban core→3% of total grids cells

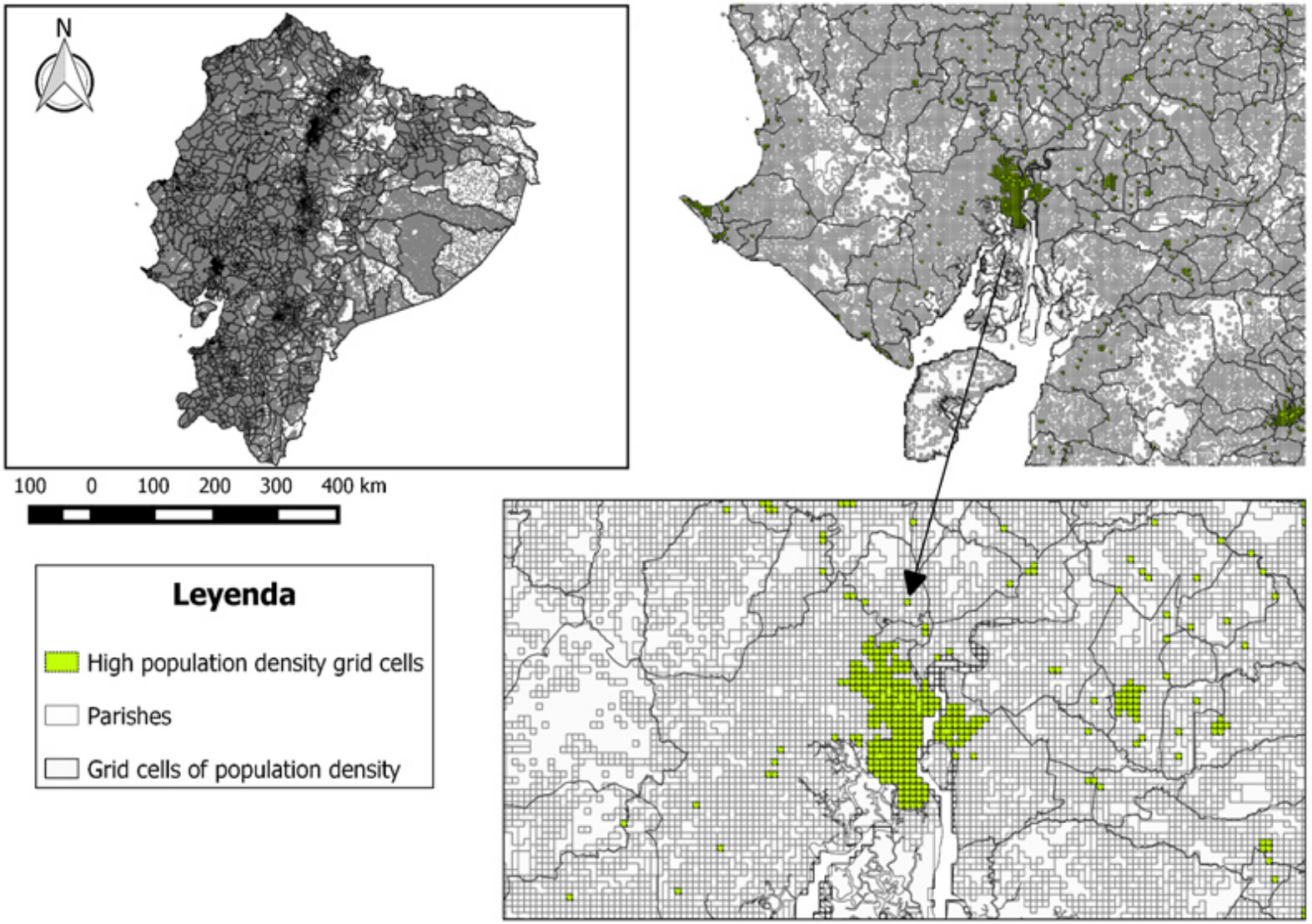
TRAVEL TIME THRESHOLD:

- SHLC 2014; 1 hour by public transport (60%)
- 30 minutes by private car
- Fixed velocity of 45km/h





1st step)


N
100 0 100 200 300 400 km
Leyenda
High population density grid cells
Parishes
Grid cells of population density

1st step)

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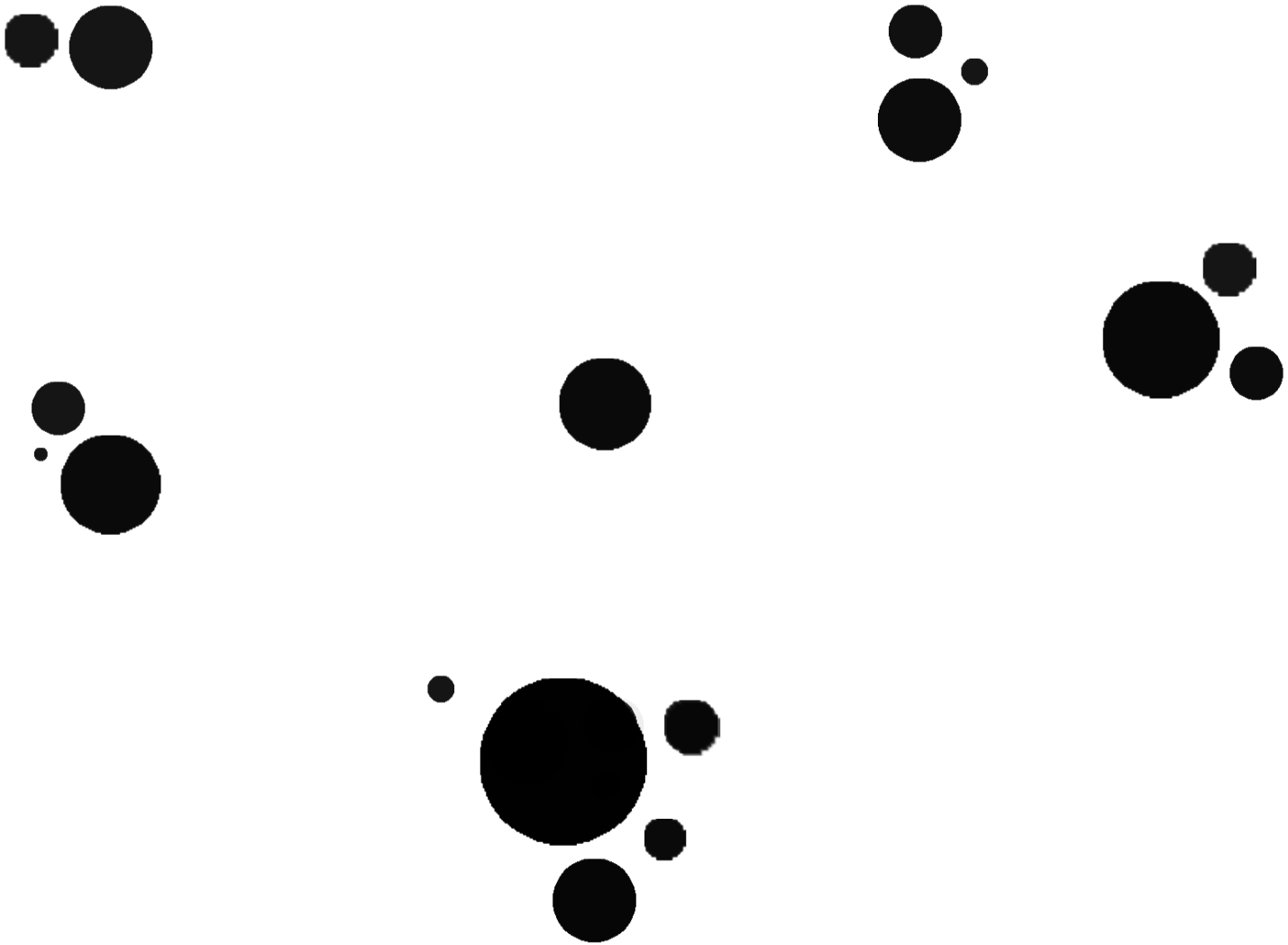
Total 34 urban cores

N	Cells	Pop	Mean	Median	Max	Min	S.D.
1	310	2553993	8238.69	5008.5	39800	0	9150.31
2	523	2166700	4142.83	1753	41536	3	4950.62
3	97	347371	3581.14	1770	39473	92	4809.74
4	80	294618	3682.73	1910.5	21696	11	4337.59
5	32	286186	8943.31	5531	31110	58	9217.87
6	123	276507	2248.02	729	19390	7	3589.86
7	41	250088	6099.71	4272	43145	91	8935.1
8	49	212192	4330.45	1891	35823	112	7233.95
9	42	180342	4293.86	1318	36652	392	7853.18
10	37	174433	4714.41	1849	19467	28	5388

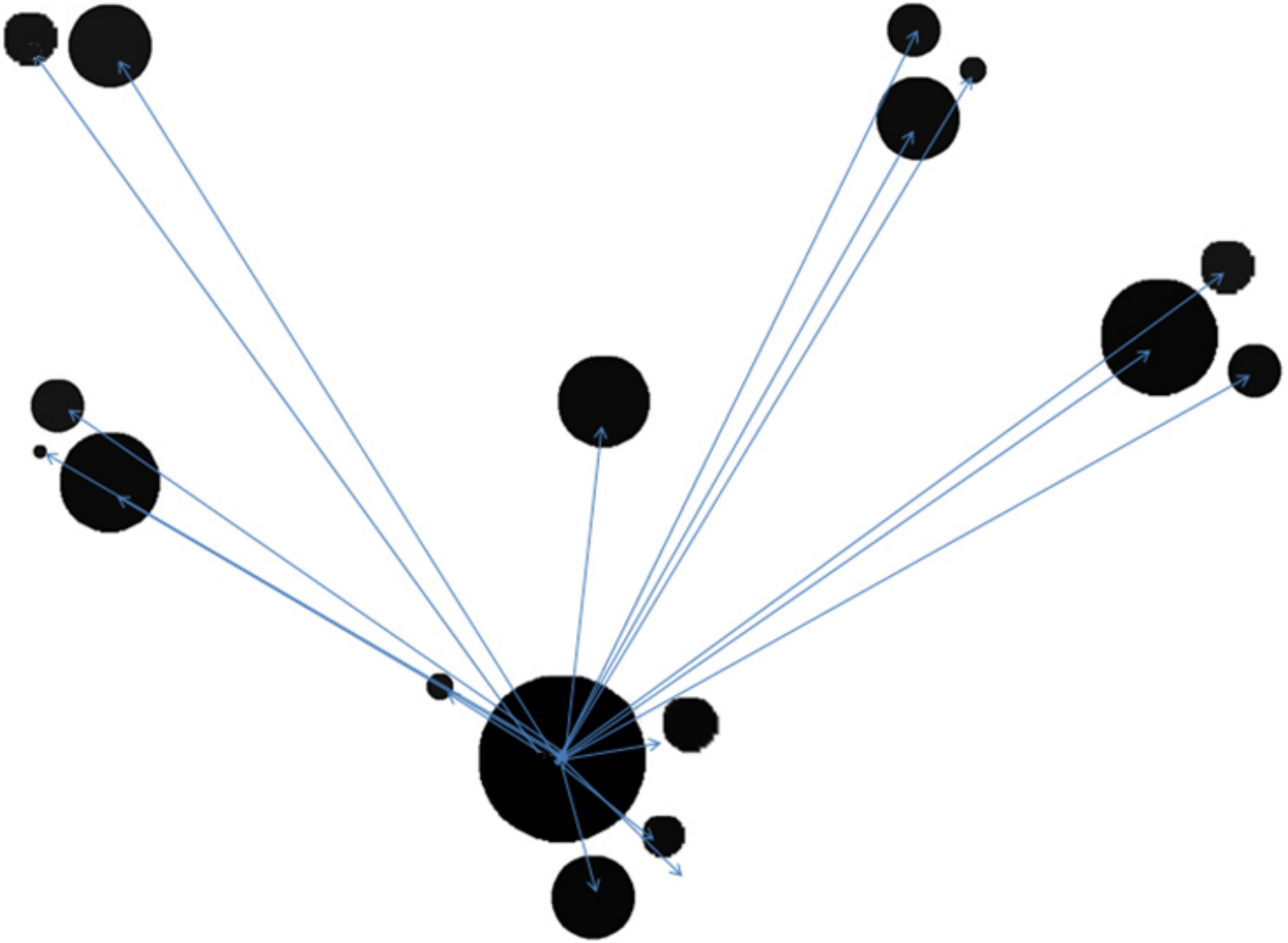
2nd step)


Las Lojas
La Clementina
Tres Postes
Yaguachi
Milagro
CHOBO
CONE
Guayaquil
Ducur
Isla Santay
Delta
Sauce
Elvira
Virgen de Fátima
Norton
San Jorge
Buena Fe
La Unión
Taura

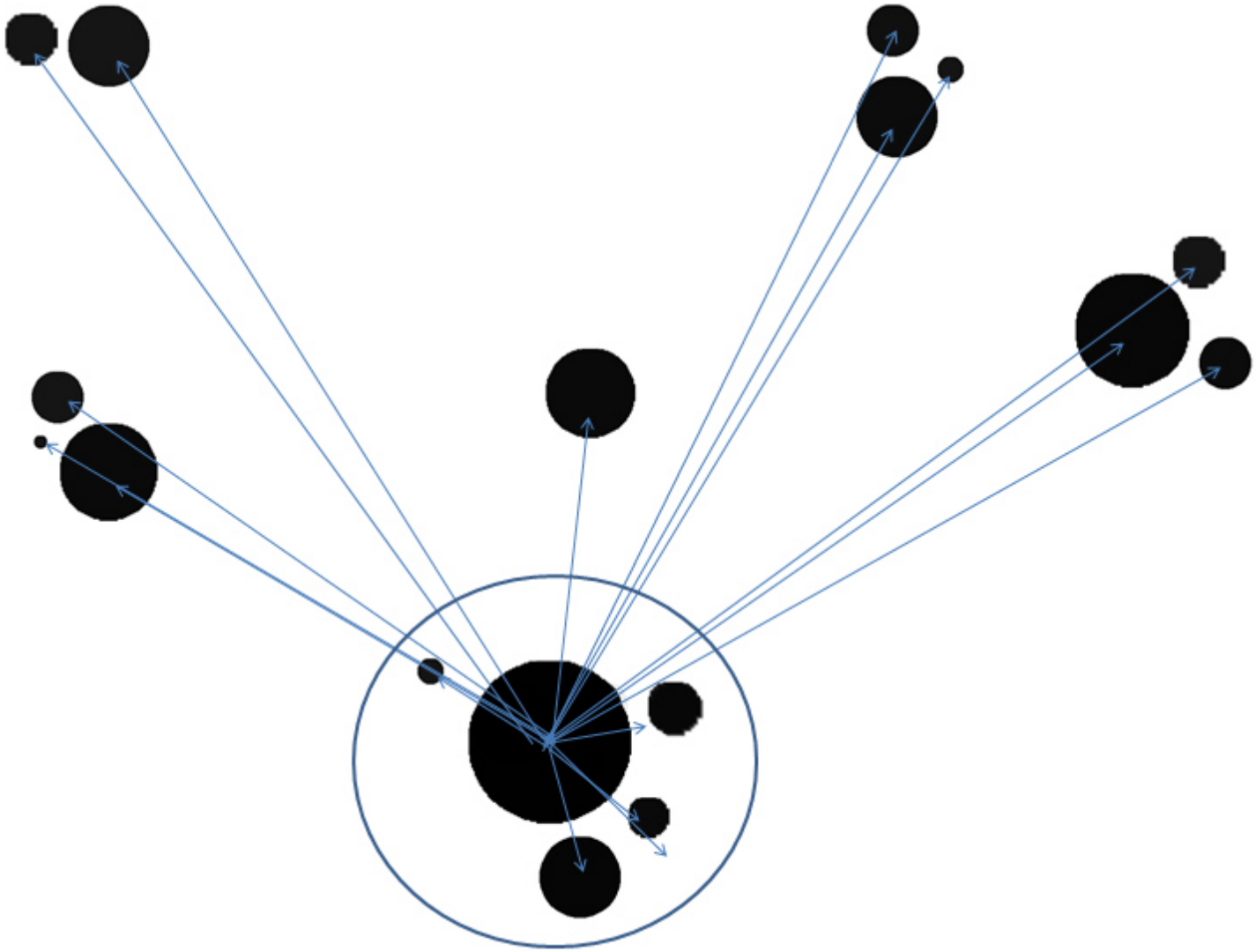
The algorithm



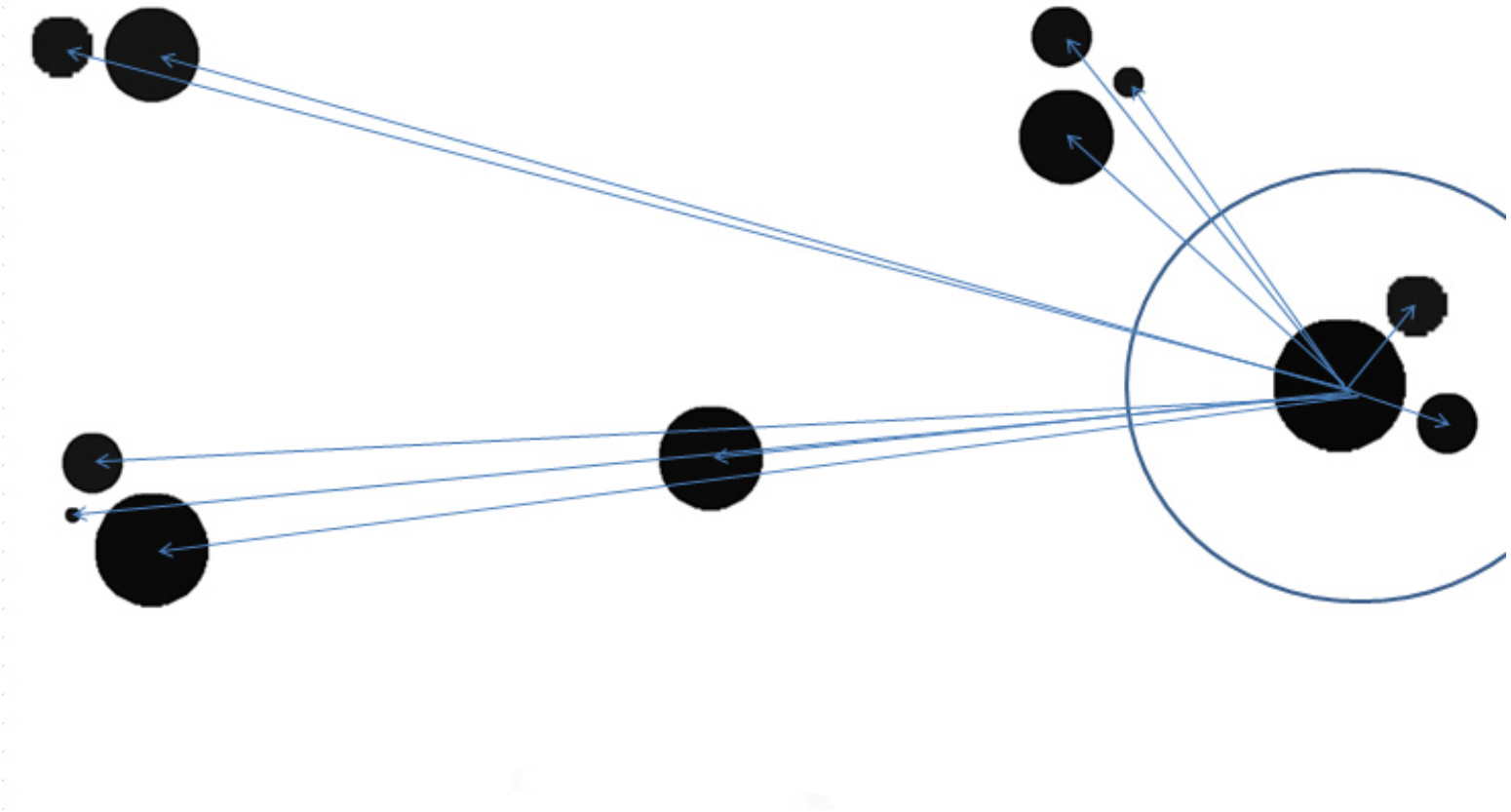
The algorithm



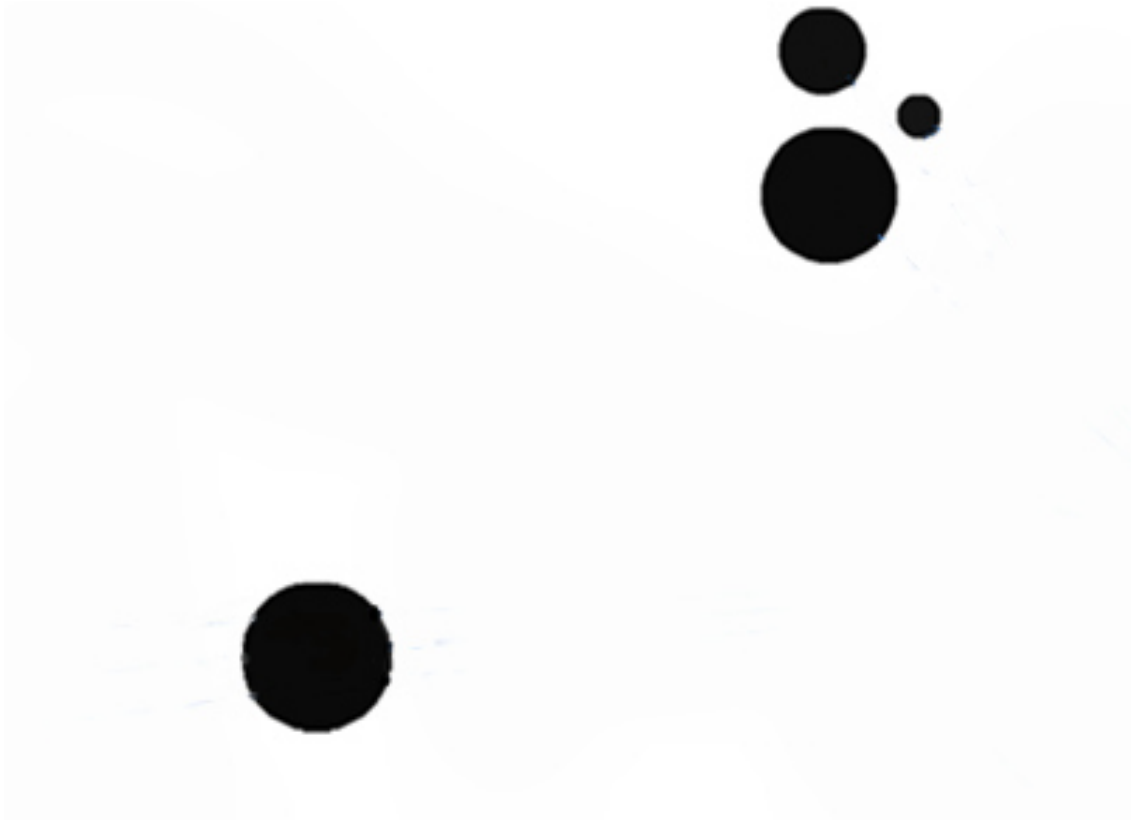
The algorithm



The algorithm



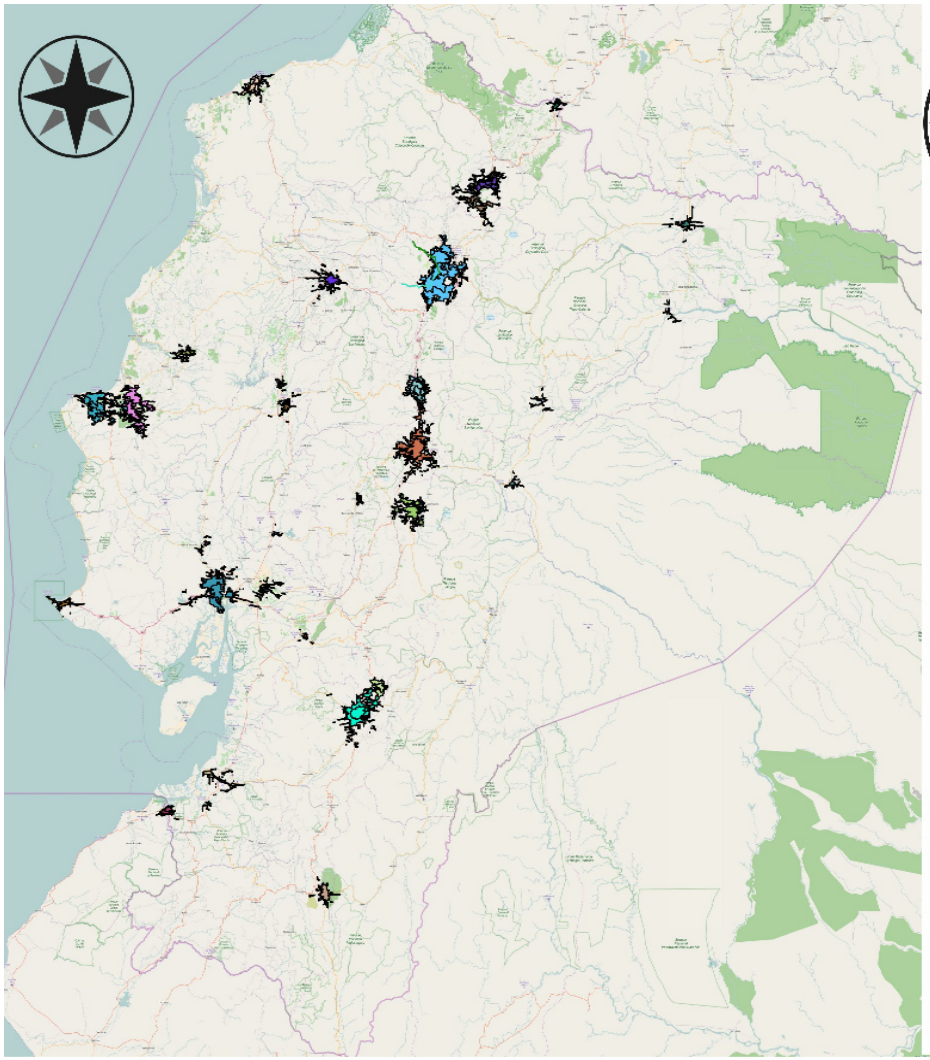
The algorithm

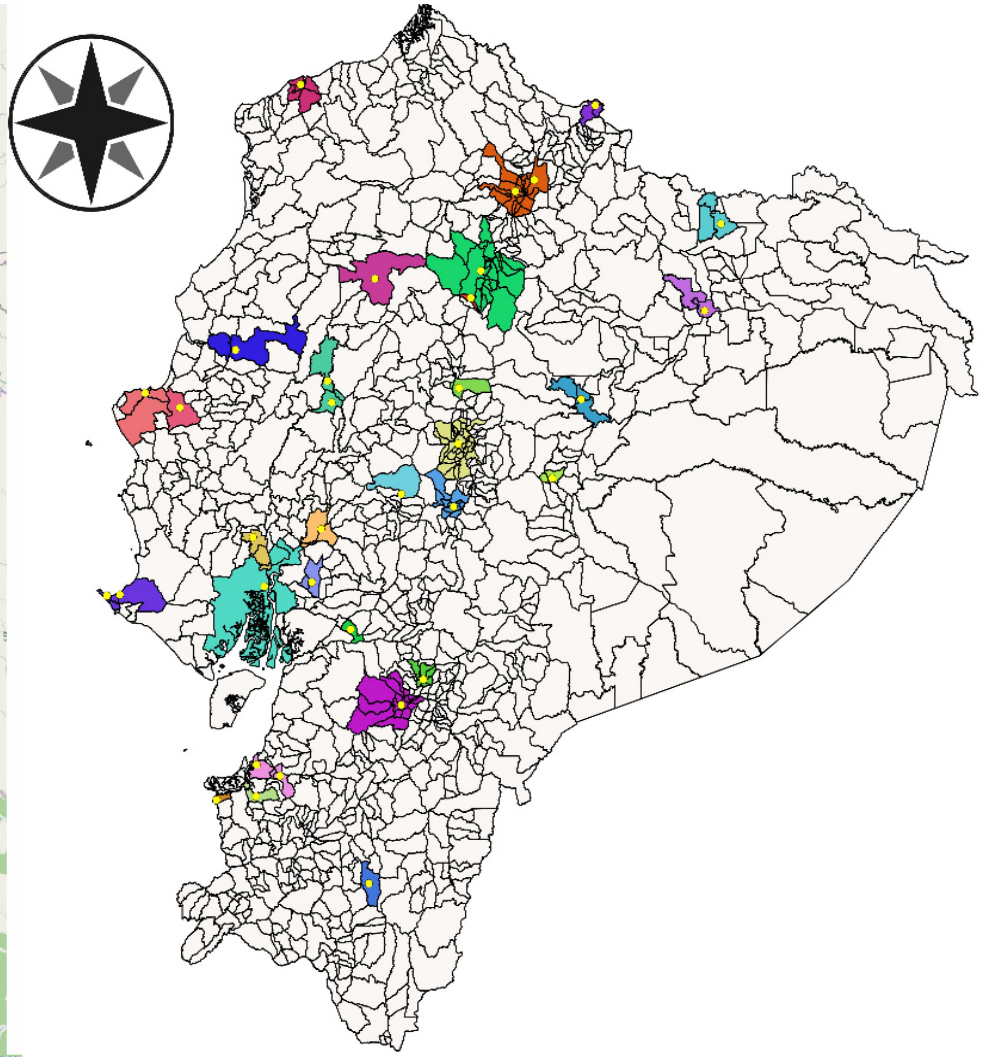


The algorithm

Application

3rd step)





Sensitivity test of urban cores based on travel time

			Initial	Results / FUAs (travel time) →			
Threshold	Grid cells	Threshold	Cores	1/2 h	1h	1h30	2h
500 inhab./km²	3,699 (3%)	25,000	34	30	23	16	13
		50,000	21	20	16	14	12
		100,000	16	15	13	12	11
1,000 inhab./km²	2,114 (1.75%)	25,000	29	28	22	15	13
		50,000	20	20	16	14	12
		100,000	16	15	13	12	11
1,500 inhab./km²	1,532 (1.25%)	25,000	33	31	22	15	14
		50,000	21	20	16	14	12
		100,000	16	15	13	12	11

Robustness checks

-Commuting patterns: Survey HLC 2014

50,000 workers; 6,800 commuters; 2,800 pairs of parishes

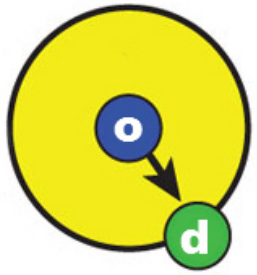
-Gravity equation: Rescale SHLC & National Census of Population 2010.

$$Flow_{o,d} = \beta_1 M_o \ \beta_2 M_d e^{-\beta_3 D}$$

-Radiation model*: National Census of population 2010.

$$F_{ij} *= F_i * \frac{Pop_i * Pop_j}{(Pop_i + w_{i,j})(Pop_i + Pop_j + w_{i,j})}$$

Do file → W_{ij} =



-Internal migration: National Census of population 2010.

(2005-2010; geographical restrictions)

Robustness checks

*Programmed in **Stata**;*

***Long do file (3 parts)**:*

-Connecting urban cores → **2nd step (O=D)**

-The hinterland (surrounded areas) → **3rd step (O!=D)**

-Combining two results list of FUA's → **Final list**

Works with: $Share\_commuters = \frac{F_{ij}}{\mathrm{Pop}_i}$

Robustness checks

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Descriptive statistics of commuters

Estimated commuters (Full matrix size)						
	OBS.	**MINIMUM**	**MAXIMUM**	**MEAN**	**MEDIAN**	**ST.DEV.**
SHLC	558,902	0	277	0.04	0	1.51
SHLC (RESCALED)	558,902	0	91,403	2.99	0	161.88
GRAVITY EQUATION	1,024,140	0	4,537	1.54	0	28.71
RADIATION MODEL	1,024,140	1.09E-12	7,563	0.94	5.49E-08	29.91
INTERNAL MIGRATION	1,024,140	1	13,453	12.03	2	98.55

Comparison table

	FUAs (1)	Min (2)	Max (3)	Mean (4)	Median (5)	St. Dev. (6)	TOTAL (7)	CV (8)
Travel time (30 minutes)	30	25,603	2,809,089	339,962	144,927	641,762	10,166,220 (64.5%)	53%
Commuting SHLC (10 %)	31	53,237	2,930,848	340,763	150,258	658,285	10,222,899 (65.15%)	52%
Commuting Gravitational (10 %)	33	37,663	2,769,539	295,143	107,129	618,271	9,739,748 (62.07%)	48%
Commuting Radiation (10%)	32	33,186	2,492,869	296,305	161,022	572,811	9,481,786 (60.05%)	52%
Migration (15 %)	29	59,312	2,558,798	417,070	280,325	634,405	11,260,940 (71.77%)	66%

Based on population 2013

Conclusions:

- Using GIS, we have enough available information to approximate integrated cities
- Travel time seems a good proxy to commuting patterns
- There is not a consensus among the best minimum threshold to work in developing countries. Although, low thresholds fit better in developing countries.
- Results become stables at very high thresholds. However, it might make invisible urban cores that can be important (e.g. Amazon region).
- The hinterland seems to be the most sensible and difficult to define.

THANKS…